RESEARCH PAPER

Socioeconomic and Environmental Basis for the Development of Small Scale Forestry in a Highly Degraded Watershed in the Venezuelan Andes

Armando Torres-Lezama · Emilio Vilanova · Hirma Ramírez-Angulo · Giancarlo Alciaturi

Abstract   In the last 20 years, the *Mocotíes* watershed in the Venezuelan Andes has experienced an intense process of land-use change, with natural forests being replaced by "sun grown coffee" (*Coffea arabica*) monocultures in sites of high slope, increasing risk conditions and the vulnerability of people living in lower parts of the watershed. Using a local-scale approach, 37 productive units (10% of total) in the *San Isidro* micro-watershed (51.85 km^2) were assessed in order to evaluate local socioeconomic conditions and perceptions of ecosystem services, and how both are affected by human activity. Almost 65% of residents work in small farms of less than 5 ha, while family ownership remains the most important form of management. A significant lack of financial support was detected, support which is required to improve coffee productivity and improve conservation practices. Severe soil loss was detected in 45% of the area, associated with cultivation on steep slopes and the use of chemical fertilizers. Agroforestry and tree planting are well-regarded, as locals tend to recognize soil protection and climate change mitigation as two of the most important ecosystem services. Using a small-scale forestry approach, it is believed that current land management could be greatly improved to: (1) progressively introduce tree cover into coffee monocultures; (2) restore degraded areas where forest cover is lost and (3) reduce deforestation. Recommended policies and actions include institutional strengthening, decentralization and the development of community-based forest enterprises. The general principles presented in this work could provide a preliminary basis for basin-wide land restoration.

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Introduction

A low proportion of global forests, close to 36%, are considered primary (FAO 2010). High rates of deforestation and degradation are still occurring, especially in the tropics, and as a consequence degraded forest lands and secondary forests cover significant areas in many tropical countries (Shono et al. 2007). This is also a very common picture in watersheds of the Andean region of Latin America, where poor management and negative environmental impacts have been documented (FAO 2004). However, since secondary forests and other degraded forest lands are usually part of subsistence agriculture systems for many rural populations (OIMT 2002), there is growing interest in the development of restoration strategies to restore biodiversity, ecological functioning and a consistent (long-term) supply of ecosystem services.

Land restoration covers a wide range of techniques and principles very closely related to landscape complexity (Lamb et al. 2005). Implementation of successful restoration projects often requires the careful treatment of several elements, including multiple stakeholders with multiple interests (local, regional and national) and the presence of complex ecological systems across a large landscape with a variety of land-uses (Gilmour 2005). Usually the first step in the restoration process is the determination of the type and severity of degradation at each site in order to define the specific objectives of restoration, which will in turn determine the course of action taken (Montagnini et al. 2008). Nevertheless, when it comes to forest landscapes a common strategy that has been used for many years involves tree planting and the use of aforestation and reforestation techniques. However, it has been argued that because of either biodiversity issues (e.g. the widespread use of monoculture based on exotic species) or social concerns (lack of participation), tree planting—especially in the tropics—is not sufficient to recover ecosystem services and to improve local livelihoods, thus hampering original restoration objectives (cf. Lamb et al. 2005).

In many countries, small-scale forestry (SSF) constitutes an opportunity to provide goods and services that cannot be produced through industrial and large-scale operations, as well as to promote poverty alleviation and development. SSF usually involves a more substantial analysis of social issues that are often misplaced or forgotten by industrial forestry projects, and also seems a much more sustainable enterprise on both social and ecological grounds (Harrison et al. 2002). SSF therefore, represents an interesting option with which to deal with the restoration and management of degraded forest lands in a more sustainable manner. Currently, few SSF projects have been properly documented in Venezuela, although an important case-study is reported in Torres-Lezama et al. (2008) regarding a mountainous area in the Andean region in the west of the country.

In the Venezuelan Andes, a significant proportion of mountainous watersheds have been severely affected by human activities thanks to the expansion of the

agricultural frontier and semi-urban settlements (Mejía et al. 2008). In the *Mocotíes* watershed, the risk of natural hazards such as landslides and flooding (resulting from the unfavourable geological, geomorphological and climatic conditions) is increased by a lack of proper land-use planning, poor bridge design and a lack of environmental management (Hernández and Valbuena 2004).

During the last 40 years, the *Mocotíes* watershed has undergone an intense process of land-use change, with natural forests replaced by "sun-grown coffee" (*Coffea arabica*) monocultures (Ataroff and Monasterio 1997) in sites of high slope which has increased high-risk conditions and the vulnerability of people living downstream. In February 2005 after unusually high rainfall, the area was affected by floods and landslides which caused severe damage (87 dead; economic loss: 80 million USD) (Ayala et al. 2005). As a result, interest in restoration strategies and planning for proper land-use management has increased in recent years. Nevertheless, the present degree of advancement of local restoration initiatives is unknown. So far, the combination of SSF approaches used within coffee cultivation seems to be mostly focused on the recovery of critical ecological properties to improve edaphic and microclimate conditions, either to improve coffee productivity or to preserve biodiversity (e.g. Wilken 1976; Gordon et al. 2007). Here, based on a local assessment (micro-watershed scale) of social and environmental conditions and perceptions of ecosystem services and environmental degradation, a preliminary basis and potential strategies for land restoration are proposed using the small-scale forestry approach.

Materials and Methods

The Study Site

The *Mocotíes* River watershed (502.36 km^2) is part of the *Chama* watershed system and the *Maracaibo* Lake influence zone, and is located within the Venezuelan Andes in *Mérida* state. The *San Isidro*, along with the *El Guayabal* and *Ovalles* micro-watersheds, shapes the *La Mejía* sub-watershed (8° 24′ 04″–8° 15′ 50″ N, 71° 40′ 50″–71° 34′ 07″ W) which is located within the *Mocotíes* watershed in the *Antonio Pinto Salinas* municipality (Fig. 1). With a total area of 51.85 km^2, the *San Isidro* micro-watershed is located between UTM coordinates 914,706–926,294 N and 209,765–217,118 E, and is characterized by the presence of Precambrian (granites, gneisses and schists) and Palaeozoic (phyllites and schists) geological units. Soils are mostly Entisols (Troporthent typical loam—fine) on the Precambrian units (*Sierra Nevada* formation), whereas the *Mucuchachí* formation (Palaeozoic) is predominated by Troporthent typical skeletal clay. Altitude varies between 700 and 3,000 m above sea level. Slopes are mostly steep (30–55%) to very steep (>55%).

According to the scheme of Koeppen and Trewartha (Rondón 1991), the local climate is classified as belonging to an isothermal humid subtropical regime (Gwbi). Mean annual rainfall varies between 1,100 and 1,350 mm with two seasons: Dry from December to May (with a mean of 88 mm/month) and Humid from June to
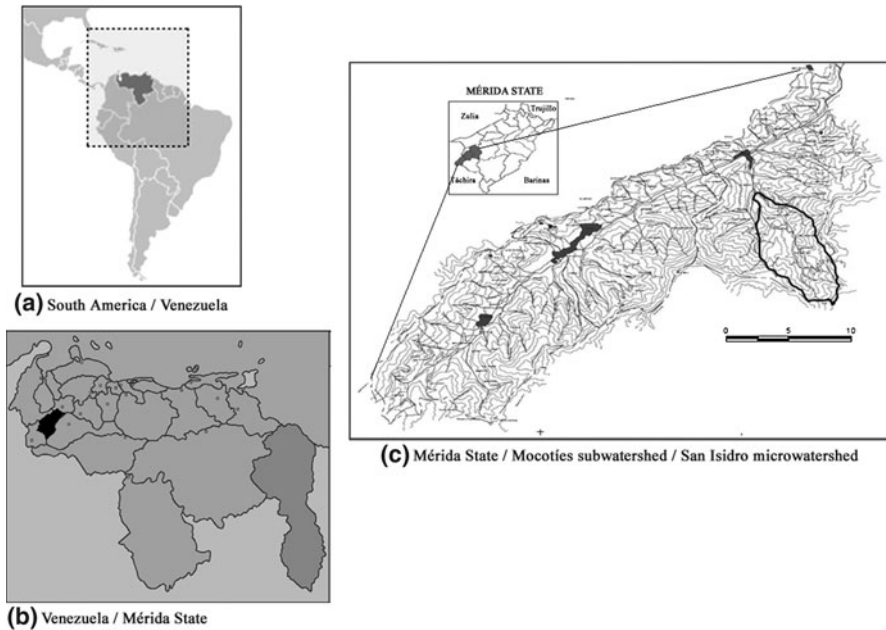
Fig. 1 Location of the study site in *Mérida* state, Venezuela. *Note* the Venezuelan map includes Guyanan territory (*dark shaded area*) claimed by *Venezuela* under the Geneva Agreement of February 7, 1966

November (135.8 mm/month). Mean annual temperature varies between 8 and 24°C. Local vegetation is comprised of species belonging to two main types of Holdridge life zones: Dry Sub-Mountainous Forests and Humid Mountainous Forests ('cloud forests'), with the latter largely located above altitudes of 2,200 m (Alciaturi 2008).

The total population residing within the *La Mejías* sub-watershed reached 5,526 by the year 2000 (González and Romero 2003). Overall population density is around 37 inhabitants per km^2; however, most of the population (84.2%) is concentrated in the urban sector of *Puerto Rico* whose area is only 3 km^2. The remaining 15.8% are located in the rural *San Isidro*, *Guayabal* and *Ovalles* micro-watersheds. In other words, although the *La Mejías* sub-watershed has a predominantly urban population, its economic base is purely rural. Furthermore, it is also worth mentioning that the population of the *Antonio Pinto Salinas* municipality was decreasing in the 1960s, a pattern associated with the dynamics of coffee cultivation. In the 1980s a slow demographic recovery commenced, although by 1990 the population had only reached levels similar to 1950 (20,625 vs. 20,445). By 2001 the population had grown to 23,273.

Land use in the area of the San Isidro micro-watershed is a complex mixture of different types of cover, of which close to 47% is cloud forest located within *Juan Pablo Peñaloza* National Park. A mixed association of coffee (mainly the

catuai variety) and banana plantations represents 32%, while 13.5% is mostly horticulture (mainly carrot production) (Fig. 2). Nonetheless, coffee production is the most important economic activity in the area (Alciaturi 2008). Management of coffee in the *San Isidro* micro-watershed essentially takes the form of "sun-grown" coffee monoculture, in which forest cover in high-slope areas has been eliminated with severe consequences in terms of biodiversity and soil conservation (Fig. 3).
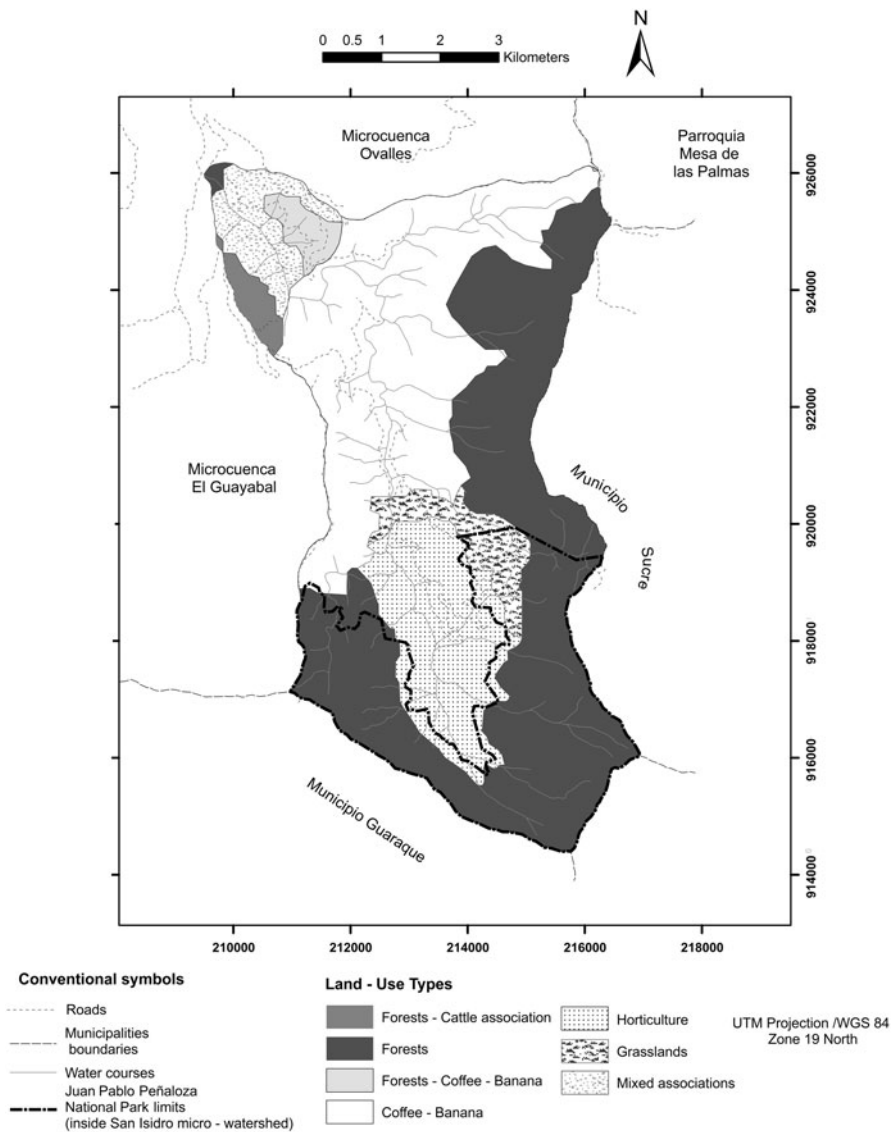

Fig. 2 Land-use map of the *San Isidro* micro-watershed in the Venezuelan Andes, *Mérida* state. *Source* Alciaturi (2008)

Fig. 3 Main features of coffee production in the *San Isidro* micro-watershed, *Mocotíes* Valley, *Mérida* state. *Photos* Emilio Vilanova

Research Methods

A combination of qualitative and quantitative methods was used to collect biophysical and socio-economic primary and secondary data, with the aim of examining conditions and sources leading to an overall characterization of the study site and the *Antonio Pinto Salinas* municipality. This analysis included both the *San Isidro* micro-watershed and *La Mejías* sub-watershed. General elements of population distribution, employment and poverty were obtained, while ecological factors potentially having a direct impact on land stability and productivity were also examined. These included parameters such as land-use capacity, use of soil conservation techniques and range of forest cover within each farm. Based on field observation and literature review, soil loss (erosion) was also considered an indicator used to estimate the current status of surveyed farms in the *San Isidro* micro-watershed.

Socio-economic and environmental assessment included structured surveys performed in 2008. The minimum sample size was estimated at 37 coffee-cultivation farms in the micro-watershed following the Cea D'Ancona (2004) methodology, with a sampling intensity of 10%. Surveys included those of several important indicators grouped in three basic areas: (1) demographic and educational profile of inhabitants; (2) general economic outline of employment and incomes; (3) land-use appreciation and environmental perception of ecosystem services. Informal surveys were also conducted with representatives of government institutions and community leaders in both the *San Isidro* micro-watershed and *Antonio Pinto Salinas* municipality. Informal dialogue and discussions were very useful during this stage. Survey data were processed by means of a spreadsheet application.

Additional effort was required to obtain an accurate geographic map database of the *San Isidro* micro-watershed. Cartographic revision included the inventory of relevant material, with the *La Mejías* sub-watershed maps (1:25,000) prepared by González and Romero (2003) very useful. A Geographical Information System (GIS) was used to develop the base map and slope sectors of the *San Isidro* micro-watershed from a cartographic—digital database. Baseline cartography

included the detailed location of coffee production areas. The polygonal of the *Juan Pablo Peñaloza* National Park in the Batallón and La Negra *páramos* (moors) was realized through the use of UTM coordinates and landforms specified within the decree creating this protected area.

Results and Discussion

Socioeconomic and Ecological Assessment

Overall, approximately 65% of inhabitants work in small production areas of less than 5 ha (Table 1), while family property remains the most important form of management. This is a common feature in the majority of coffee-producing areas across the *Mocotíes* Valley (Alciaturi 2008). Close to 70% of production is dedicated to commercial use in *Mérida* state and the rest of the Andean region through local associations. In all cases a combination of small and large farms is used for commercial purposes. Nevertheless, close to a third of commercial coffee is derived from larger farms (>5 ha), with the remaining coffee production—largely used for self-consumption—from smaller farms. Recent controversial government reform of land property legislation has prompted the discussion of the use of private versus state (public) property for national development. As a consequence, in many cases—especially in rural areas like the *San Isidro* micro-watershed—the process of collecting information about many aspects of land management (e.g. surface, tenure rights) has become a major problem, since local communities are hesitant to speak when such issues are raised during social assessment.

Since 1950, a consistent shift in land property has occurred in the *Mocotíes* Valley, from large producers to family-run and other smaller-scale forms of management. Migration to urban areas has been widely documented, especially that occurring between 1950 and 1960, as a consequence of global coffee market fluctuations (Alciaturi 2008). After being the leading state in national coffee production, a decrease in production in the Venezuelan Andes has been documented since 2002, with two other states (Portuguesa and Lara) now the top producers at a national scale (Rojas-López 2007). The Agriculture Ministry, a governmental institution, has reported a consistent decrease in the cultivated area of coffee

Table 1 Distribution and extent of coffee production areas in the San Isidro micro-watershed	Total surface area (ha)	Number of production units (farms)	Relative frequency (%)
	Up to 2	10	27.03
	2.1–5	14	37.84
	5.1–10	5	13.51
	10.1–20	2	5.40
[a] People surveyed were reluctant to offer this information	Without data[a]	6	16.22
	Total	37	100

Table 2 Cultivated land area used for coffee production in the *Antonio Pinto Salinas* municipality	Year	Coffee cultivated area (ha)
	1995	8,356
	1996	8,356
	1997	8,400
	1998	7,453
	1999	5,657
	2000	5,043
	2001	6,820
	2002	4,000
	2003	4,000
	2004	3,836
Source MAT (2007)	2005	2,372

production in the *Pinto Salinas* municipality since 1995, from 8,356 to 2,372 ha (Table 2).

Technological improvements, including the use of high-yield varieties of *Coffea arabica*, are often economically unobtainable for small farmers, leading to the eventual abandonment of land and modification of traditional forms of employment (Cartay 1999; Rojas-López 2007). In many ways, depending on the degree of technical land management, small farmers have become the most vulnerable groups when a market crisis occurs. The results of the *San Isidro* survey reveal that less than 36% of residents are effectively working in coffee production, including those cases in which coffee cultivation is part of a mixture of associations, as shown in the land-use map in Fig. 2. The functioning of these mixed associations of coffee with other crops and land-use activities is highly dependent on the fluctuation of coffee market prices. As expected, priority is given to coffee cultivation in cases where the market offers opportunities for improving economic return. In recent years, however, decreases in coffee prices have led local and regional government institutions to develop an ambitious plan to promote the establishment of citrus plantations in some areas of the Andean region of Mérida state, including the *Mocotíes* Valley (for further details see http://www.corpoandes.gov.ve/?q=node/545). The results of these programs still require careful assessment.

An additional outcome of the survey was the revelation that the reduction in cultivated area of coffee plantations has resulted in most smaller farms (75%), run in the past for commercial purposes, being currently catalogued as subsistence and self-consumption farms. Economic investment is usually low and mostly used for fertilizers and infrastructure. Only 20% of farmers report the use of credits or any other form of economic incentive to improve agricultural activities.

Severe soil loss was detected for 45% of the area of surveyed farms carrying out cultivation on high slopes and using chemical fertilizer. Critical conditions and clear evidence of soil loss were mostly observed on farms at which coffee was grown in association with other crops (mostly banana). At these farms, producers tended to manage their land in a more intensive manner in terms of soil preparation, use of chemicals and reduction of tree cover to promote growth of "sun-grown" coffee

plantations. Signs of erosion were also observed on smaller farms cultivating short-term crops without low land cover.

Although there has been intense debate as to whether coffee production should be carried out using "shadow trees" to improve crop productivity (see DaMatta and Rodríguez 2007 for more details), it is generally highly recommended—especially for the high altitude agriculture typical of the Venezuelan Andes—that soil conservation be improved by the use of different forms or combinations of tree species (FAO 2000a). In order to compare the proportion of soil loss under different forms of coffee management, Ataroff and Monasterio (1997) carried out a study in the region of *Canaguá*, in Mérida state very close to the *Mocotíes* Valley area. Data were obtained by analyzing the successive loss of the mineral fraction and runoff under three different tree cover conditions, from a 1–2 years "sun-grown" coffee plantation to a 16–17 year-old shaded plantation. The results of the study revealed that larger losses were found at the sun plantation.

Although some tree species from original forests are often replanted, such as *Cordia alliodora*, *Inga* spp. and *Erythrina* spp., among others (Ataroff and Monasterio 1997), many coffee production systems in the tropics use citrus species, avocados (*Persea americana*) and bananas (*Musa* spp.) as a diversified method of land management (DaMatta and Rodríguez 2007). In addition, with the appropriate selection of species, an increase in forest cover would have connective benefits for other ecosystem services such as pollination for coffee production (Ricketts et al. 2004). In general, such systems would involve less intensive interventions—for example; less drainage, less intensive tillage, less reliance on large machinery and reduced usage of artificial fertilizers, pesticides and fungicides. The latter would provide more room for nature alongside crops, and in many cases create habitats in which wildlife can thrive (Amend et al. 2008). Although no economic data were collected, informal dialogue revealed that farmers were willing to cultivate coffee under shade if given similar incentives to those once received for farming sun-grown coffee. For example, Gordon et al. (2007) reported that high-biodiversity coffee cultivation in the central Veracruz area in Mexico can be compatible with high profitability, as well as having significant potential to conserve biodiversity in coffee-growing regions.

In the *San Isidro* micro-watershed, almost 38% of surveyed farms contained, amongst a diverse range of vegetation types, small remnants of cloud forest. A small proportion of owners (27%) indicated the sporadic use of small-scale logging for wood products. An important fact that should be addressed here is that the current lack of monitoring and available statistical data precludes a more detailed analysis to be made of the potential impact of wood extraction as a cause of deforestation in the area. Nonetheless, informal surveys of government institutions have revealed an apparent reduction in illegal logging in the last 10 years (Alciaturi 2008). For instance in the Andean region of Venezuela, cattle farming and subsistence crop cultivation are considered the two major forces behind degradation and deforestation (see for example the analysis made of three different micro-watersheds by Pozzobon et al. 2004).

In terms of the current status of ecosystem services, about 40% of locals recognized the existence of severe environmental problems—mostly regarding poor

water quality caused by intensive use of agrochemicals. Although there is an apparently good social perception of how ecosystem services are functioning, in all cases it was acknowledged that recent flooding events and reduced coffee productivity could have been influenced by reductions in forest cover and deforestation. Nevertheless, more accurate analysis of the potential links between loss of forest cover and other ecosystem services such as pollination and regulation of erosion is still needed. The rapid assessments carried out as part of the present study, however, indicate that regulation is critical and key to other services such as the provision of water, wood and food.

Survey results revealed a very vague and diffuse local perception of how environmental issues should be addressed in order to improve ecosystem services, conservation and local livelihoods. For instance, only 24% of those questioned acknowledged the relevance of the presence of the *Juan Pablo Peñaloza* National Park within the *San Isidro* watershed. Local awareness of the direct benefits obtained from natural ecosystems—such as potable water and soil conservation, as two of the most valuable services in the area—was very poor, revealing a very weak link between protected areas and local communities. In a national-scale analysis of the Venezuelan protected areas system, Bevilacqua et al. (2006) found similar patterns in a high proportion of areas located near populated sites.

In terms of restoration and conservation, close to 37% of locals were able to provide some ideas regarding potential practices related to a more sustainable management of coffee production and the watershed as a whole. Reforestation was the most common recommendation proposed; the inclusion of tree cover in coffee cultivation areas (using a variety of methods) was considered to be a sound alternative to reduce natural degradation. However, this practice has several limitations in terms of potential constraints for coffee productivity, including species competition, increases in pest susceptibility and a reduction in the ability to carry out mechanized agricultural operations, among others (DaMatta and Rodríguez 2007). In the *San Isidro* micro-watershed, farmers of sites located in higher altitude areas were uncertain of the benefits of the wide-spread use of trees in coffee plantations. High cloud density, limited solar radiation and lower temperatures are already known to be limiting factors for both sun-grown coffee cultivation and long-term productivity. As a consequence, the SSF approach discussed in the following section must take into account this important fact.

The Small-Scale Forestry (SSF) Approach

Based on results obtained from a local-scale analysis of the *San Isidro* micro-watershed, the proposed use of the general principles of SSF (here defined as all activities relating to forest ownership, plantation management, legislation, institutional participation and potential creation of local forest-based enterprises) is intended to: (1) progressively introduce tree cover into coffee monocultures; (2) restore degraded areas in which forest cover has been lost and (3) reduce deforestation in the *Mocotíes* watershed. In the context of the restoration of degraded areas of the watershed, the SSF approach brings together ecological elements—to improve and sustain vital ecosystem services via the prevention of

erosion in a highly vulnerable area—and the social needs and livelihoods of local communities.

Using Trees in Coffee Plantations in the Mocotíes Watershed

The complex synergy between ecological and physiological elements involved in the process of incorporating tree species within coffee plantations in the *Mocotíes* watershed requires in-depth analysis beyond the scope of this paper. However, general working rules will be discussed here in order to enhance the potential of small-scale forestry (SSF) in the area. Firstly, the general principles of SSF can be applied to highlight the ability of soil conservation in reducing the risks facing and vulnerability of local communities. Collateral action supporting this idea would require attention to be given to how plant species other than trees could be used in multiple-land-use planning. This would necessarily involve the use of a zoned analysis to identify potential uses for trees basin-wide. For instance, high altitude farms (>2,000 m) could incorporate tree species under live fence systems, and other plant species (grasses and small shrubs) within cultivation plots to improve soil protection.

Social assessment carried out in this study revealed a progressive decrease in recent years in local dependence on coffee production as the most important economic activity. As farming practices change, the cultural landscapes that have developed from them are also eroded or abandoned. In some cases, changes in land-use have been accompanied and motivated by economic factors. In fact, with field observation and informal dialogue providing evidence of the growth of the use of citrus tree species, such changes offer an opportunity to accomplish the goal proposed here of incorporating tree cover in coffee cultivation farms. An important goal of the SSF approach of using trees in coffee plantations is not only to increase "shading", but also to enhance local agro-biodiversity and other relevant ecosystem services. In most 'developing' countries—traditionally home to much of the world's agro-biodiversity—monocultural models of agricultural 'development' have for decades pushed out diverse traditional systems and encouraged or coerced farmers to switch to a smaller number of varieties (Amend et al. 2008). In terms of improving ecosystem services, reasons for the incorporation of tree species into coffee monocultures include their use as a source of timber, fuel wood and fruit production, as well as the provision of direct ecological benefits such as increased biodiversity and carbon sequestration (Borkhataria et al. 2011; Dossa et al. 2008). Based on survey data, the middle- (between 2,000 and 1,000 m altitude) and lower-lying parts (<1,000 m) of watersheds are perhaps the most suitable areas, since, at least in the case of the *San Isidro* micro-watershed, social acceptance is higher in these areas.

The establishment of tree species affects not only the landscape and environment, but also local communities. Consequently, priority should be given to an analysis of current laws and regulations that determine land-use patterns on public and private land, in order to reach regional and local agreements that support social acceptance of SSF projects, thus providing a more open process of information exchange between all stakeholders. In addition, the process of species selection requires a

careful consideration of the potential effects in terms of environmental impact. Alteration of biodiversity, water resources (e.g. water quality and quantity) and soil fertility are the most commonly-mentioned effects (Cossalter and Pye-Smith 2003; Schirmer 2007). Negative environmental impact can be reduced considerably if the selected species match social requirements (as considered in this study) and if management is appropriate, including the adequate selection of seed sources, nursery and plant production control, and planning of silvicultural treatments. An example of species selection for an SSF project in Venezuela can be found in Torres-Lezama et al. (2009).

SSF for Restoration of Degraded Land

In the context of this paper, restoration of the *Mocotíes* watershed represents a process that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest areas (Maginnis and Jackson 2005). Undoubtedly, such a complex goal requires a similarly complex approach in order to fully understand the links between stakeholders, ecosystem dynamics and, perhaps most importantly, the interrelation between people and the ecosystem services which sustain vital functions and activities. Multi-stakeholder processes essentially offer a new working mechanism with which to introduce a broader understanding and encouragement of respect between all stakeholders (Yuliani et al. 2006). Applying a landscape-level approach to site-level management could lead to both healthier landscapes and an improvement in stand-level management.

As mentioned previously, the incorporation of trees through plantation within the *Mocotíes* watershed definitely deserves a place in the restoration process. However, since restoration implies multiple objectives, a realistic and pragmatic vision is required in order to understand what forest plantations are capable of delivering, as well as to recognize that other functions and spaces within the landscape need to be created so that other complementary restoration strategies can be deployed (Maginnis and Jackson 2005). The SSF approach can be adapted to fit within a more integrated and developed strategy in which alternatives such as the promotion and enhancement of natural forest recovery, assisted natural regeneration and enrichment planting are evaluated (Lamb et al. 2005; Shono et al. 2007). However, evaluation of potential restoration strategies in the *Mocotíes* watershed would need to pay attention to the condition of those areas with potential for restoration. Coffee cultivation systems in the *Mocotíes* area fit more appropriately into commercial-intensive schemes (Fig. 4) that potentially represent a higher cost in terms of restoration. The progressive implementation of SSF scenarios would offer a wide variety of opportunities to absorb these costs.

Reducing Deforestation Through Small Scale Forestry

The paucity of up-to-date statistics regarding the state of forest cover in Venezuela is well-documented in several technical reports (e.g. GFW 2000; Torres-Lezama
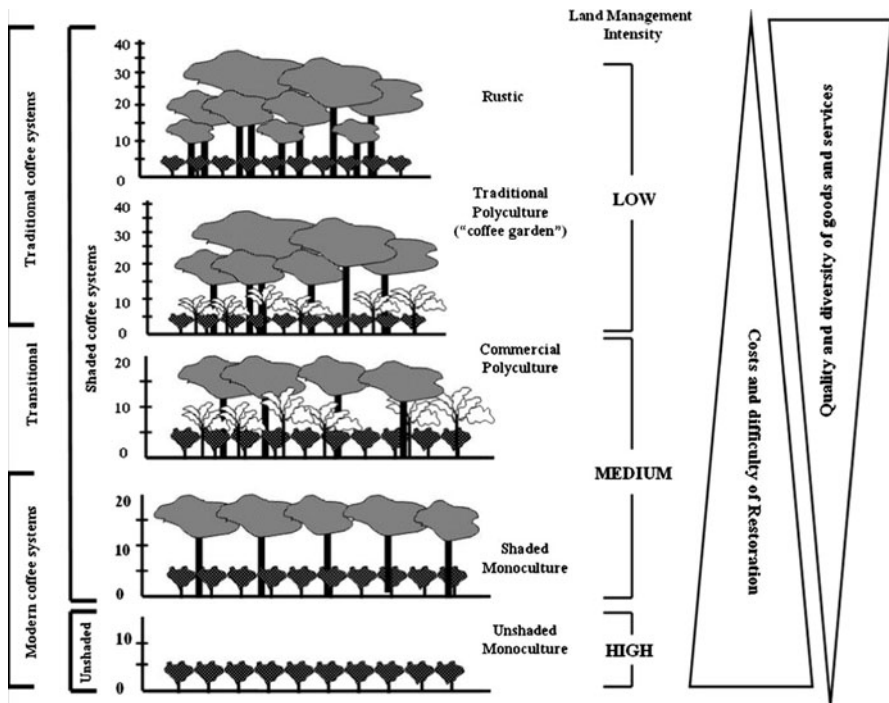
Fig. 4 Restoration conditions for five common coffee production systems in the tropics. *Source* Adapted from Moguel and Toledo (1999) and Aronson et al. (2007)

et al. 2008). As a consequence, current analysis and research into forest-related problems is severely limited. Based on FAO statistics (FAO 2000b), *Mérida* state lost close to 122,000 ha (−1.65% annual) between 1975 and 1988, with the total forest area reduced to 498,700 ha by the end of the period. Almost a decade later, forest cover had decreased to 388,680 ha (34.4% of the total area of Mérida state). In spite of not having precise statistics relating specifically to the *Mocotíes* watershed, several studies have reported higher deforestation rates occurring in mountainous watersheds (Hernández and Pozzobon 2002; Pozzobon et al. 2004).

Approximately 46% of the *San Isidro* micro-watershed is covered by forests—most of which are found within a National Park situated at an altitude of 2,200 metres and above. However, as shown in Fig. 2, several areas of different types of forest-crop associations still cover a significant part of the *San Isidro* area, without any formal or legal protection. The use of wood and other forest-related goods, as revealed here by social assessment, is not highly appreciated by local communities. Nonetheless, progressive elimination of forest cover has taken place since the initial establishment of shaded coffee plantations, with the transition to sun-grown coffee varieties affecting forests and biodiversity. Although there is an intense debate as to the ability of forestry plantations to reduce pressure on natural forests (see Cossalter and Pye-Smith 2003 for more details), it is believed that small scale forestry alternatives such as those proposed here offer the opportunity for forest remnant

conservation by reducing human pressure in the form of agricultural expansion. Agroforestry technologies such as improved fallow and live fences, as well as methods of direct reforestation or afforestation, could provide a multi-faceted strategy of land management. Forest remnants would offer ecosystem services such as carbon sequestration, biodiversity conservation and water regulation, which are widely acknowledged as being beneficial by local communities. Additionally, strengthening the link between local people and the *Juan Pablo Peñaloza* National Park through ecotourism activities could provide new forms of management in the *Mocotíes* watershed.

Guiding Small-Scale Forestry Practices and Policy Recommendations

A well-balanced interaction between the public and private sectors, and a well-designed policy of incentives is needed in order to properly implement SSF management, not only in the *Mocotíes* area, but throughout rural Venezuela. The opportunity for SSF remains because current forestry law includes a novel incentives policy for new socio-productive mechanisms favouring small-scale operations. This policy also includes encouragement of social participation and empowerment through economic incentives, including tax concessions and financial support. In terms of taxes, the national government has focused on the implementation of land-use systems that are both environmentally-friendly and in which tree planting is a viable economic strategy. For instance, Nawir et al. (2007) report an example of how national forest policy could provide an opening for small farmers by offering tax incentives that are proportionate to the number of trees they plant. Financial support, from both the private sector and the government, includes a wide range of packages that can include plantation establishment funds, physical inputs, free seedlings, paid labour for government projects and loan schemes. However, in order to be effective, such proposed financial incentives require supporting policies and conditions such as secure tenure of land and clear mechanisms for funding support, avoiding the discrimination of less favoured groups.

   Coffee production in combination with other forest products and services could assist in poverty reduction and provide livelihoods for most of the population. FAO guidelines for Market Analysis and Development (MA & D)—described by Lecup and Nicholson (2006) and ITTO (2007)—outline a promising approach with which to deal with the social complexity involved in the creation of community forest-based enterprises (CFEs). In order to facilitate CFEs, several conditions must be met, including: (1) a multi-product strategy incorporating better practices for coffee production, agroforestry management and non-timber forest products; (2) restructuring of land tenure; (3) promotion of new political institutions and (4) a shift in economic decision-making from the household to the collective level, aimed at greater participation in the market economy. These conditions have so far been neglected in most rural areas of the Andean region of Venezuela, severely affecting the functioning of local enterprises and small-scale initiatives in which most activities rely on forests and agro-ecosystems.

Special attention should be given to informal arrangements such as customary property rights and other pre-existing rules of community forest management that have not been officially codified in law. Within enterprise development, a systematic monitoring process is required to oversee those issues that are critical for linking CFE with potential buyers of coffee, wood and other forest products and services. These include quality improvement, certification and development of effective administrative and market procedures (Donovan et al. 2008). A number of promising sustainable coffee production projects are currently being undertaken in several parts of the Venezuelan Andes that could be used to model the potential *Mocotíes* experience.

Conclusions

During the last 30 years, land use in the *Mocotíes* watershed has experienced an intensive transformation involving the use of landscapes mainly for coffee production and other agricultural activities which have severely affected ecosystem stability. Traditional coffee production systems have also been modified via the application of more intensive land management systems which have amplified the intensity of environmental impact. Critical regulation services such as erosion control appear to be the most affected, but also the most widely acknowledged by local communities. As a consequence the environment has been highly degraded, with the entire watershed system affected by an increase in risks and vulnerability. Other linked services, including the provision of water and overall coffee productivity could also be affected in the long term.

A combination of ecological, economic and social forces in the *Mocotíes* watershed—and in the Andean region of Venezuela as a whole—has resulted in a complex situation in which small-scale forestry could have great potential. Social assessment has helped to outline three complementary potential strategies based on the general principles of small-scale forestry: (1) increasing tree cover in coffee plantations; (2) SSF as part of a restoration program, and (3) SSF to reduce deforestation. It should not be ignored that SSF must overcome serious challenges if it is to be successfully implemented in this watershed. For instance, a lack of incentives and a very weak institutional framework threaten the potential benefits of the SSF strategies presented here. The integrated planning and policy approaches discussed in this paper could contribute to social and economic development by offering decision-makers a range of options for sustainable development. Social networking and community associations closely linked to research institutions should provide a promising method of improving both local livelihoods and ecosystem conservation.

References

Alciaturi G (2008) Estudio socio-ambiental de la microcuenca cafetalera San Isidro, Estado Mérida—Venezuela. Trabajo Especial de Grado. Universidad de Los Andes, Facultad de Ciencias Forestales y Ambientales, Escuela de Geografía, Mérida

Amend T, Brown J, Kothari A, Phillips A, Stolton S (eds) (2008) Protected landscapes and agrobiodiversity values. Protected landscapes and seascapes, vol 1. IUCN & GTZ, Kasparek Verlag, Heidelberg

Aronson J, Milton S, Blignaut J (eds) (2007) Restoring natural capital: science, business, and practice. Island Press, Washington DC

Ataroff M, Monasterio M (1997) Soil erosion under different management of coffee plantations in the Venezuelan Andes. Soil Technol 11(1):95–108. doi:10.1016/S0933-3630(96)00118-3

Ayala R, Páez G, Araque F (2007) Análisis geomorfológico de la microcuenca El Guayabal, a propósito de la ocurrencia de las lluvias excepcionales de febrero de 2005. Cuenca del río Mocotíes, estado Mérida-Venezuela. Revista Geográfica Venezolana 48(1):59–82

Bevilacqua M, Cárdenas L, Medina D (2006) Las áreas protegidas en Venezuela: diagnóstico de su condición 1993/2004. Fundación Empresas Polar, Caracas

Borkhataria R, Collazo JA, Groom MJ, Jordan-Garcia A (2011) Shade-grown coffee in Puerto Rico: opportunities to preserve biodiversity while reinvigorating a struggling agricultural commodity. Agric Ecosyst Environ. Corrected Proof. doi:10.1016/j.agee.2010.12.023 (in press)

Cartay R (1999) Estrategias de sobrevivencia de los pequeños caficultores en tiempos de crisis. Agroalimentaria CIAAL—FACES—ULA 9(1):79–82 (Mérida, Venezuela)

Cea D' Ancona M (2004) Métodos de Encuesta. Teoría y práctica, errores y mejora, Madrid, Síntesis

Cossalter C, Pye-Smith C (2003) Fast-wood forestry: myths and realities. Centre for International Forestry Research (CIFOR), Bogor

DaMatta F, Rodríguez N (2007) Producción sostenible de cafetales en sistemas agroforestales del neotrópico: una visión agronómica y ecofisiológica. Agronomía Colombiana 25(1):113–123

Donovan J, Stoian D, Poole N (2008) Global review of rural community enterprises: the long and winding road to creating viable businesses, and potential shortcuts. Tropical Agricultural Research and Higher Education Center (CATIE) Technical Series, Technical Bulletin N°. 29, Collection N° 2. Turrialba, Costa Rica

Dossa E, Fernandes E, Reid W, Ezui K (2008) Above and belowground biomass, nutrient and carbon stocks contrasting an open-grown and a shaded coffee plantation. Agrofor Syst 72:103–115

Food and Agricultural Organization (FAO) (2000a) Manual de prácticas integradas de manejo y conservación de suelos. Boletín de Tierras y Aguas de la FAO N° 8. Roma

Food and Agricultural Organization (FAO)—Forest Resource Assessment (2000b) Bibliografía comentada: cambios en la cobertura forestal Venezuela. Working paper 39. Rome

Food and Agricultural Organization (FAO) (2004) Watershed management case study: Latin America. Review and assessment of the status of watershed management. Rome

Food and Agricultural Organization (FAO) (2010) Forest resource assesment FRA 2010: Key findings. http://www.fao.org/forestry/static/data/fra2010/KeyFindings-en.pdf. Accessed 25 Mar 2010

Gilmour D (2005) Applying an adaptive management approach in forest landscape restoration. In: International tropical timber organization (ITTO) restoring forest landscapes: an introduction to the art and science of forest landscape restoration. ITTO Technical Series 23: 35–43 (Yokohama, Japan)

Global Forest Watch (GFW) (2000) The State of Venezuela's forest: a case study of the Guayana Region. Global Forest Watch, Venezuelan Chapter-WRI-Fundación Polar, Caracas

González E, Romero D (2003) Estudio preliminar de la disponibilidad, demanda y calidad del agua en la subcuenca Quebrada Mejías (Municipio Antonio Pinto Salinas—Estado Mérida). Trabajo especial de grado. Universidad de Los Andes, Mérida

Gordon C, Manson R, Sundberg J, Cruz-Angón A (2007) Biodiversity, profitability, and vegetation structure in a Mexican coffee agroecosystem. Agric Ecosyst Environ 118(14):256–266. doi:10.1016/j.agee.2006.05.023

Harrison S, Herborn J, Niskanen A (2002) Non-industrial, smallholder, small-scale and family forestry: what's in a name? Small-scale forest economics. Manag Policy 1(1):1–11

Hernández E, Pozzobon E (2002) Tasas de deforestación en cuatro cuencas montañosas del Occidente de Venezuela. Revista Forestal Venezolana 46(1):35–42

Hernández E, Valbuena J (2004) Las amenazas naturales, los riesgos y la vulnerabilidad ambiental del doblamiento en el eje Chama-Mocotíes. Mérida—Venezuela. IV Simposio Internacional de Desarrollo Sustentable en Los Andes. http://hoeger.com.ve/ama/. Accessed 15 Mar 2010

ITTO (International Tropical Timber Organization) (2007) Community based forest enterprises: Their status and potential in tropical countries. Technical Series 28. Yokohama

Lamb D, Erskine P, Parrotta J (2005) Restoration of degraded tropical forest landscapes. Science 310:1628–1632

Lecup I, Nicholson K (2006) Community-based tree and forest product enterprises: market analysis and development. Revised Booklet B Introduction: defining where you want to end up. FAO, Rome. ftp://ftp.fao.org/docrep/fao/009/j8712e/j8712e00.pdf. Accessed 15 May 2008

Maginnis S, Jackson W (2005) What is forest landscape restoration and how does it differ from current approaches? In: International tropical timber organization (ITTO) restoring forest landscapes: an introduction to the art and science of forest landscape restoration. ITTO Technical Series 23:15–27 (Yokohama, Japan)

Mejía J, Páez G, Boada J (2008) Prioridades de conservación del recurso agua en la cuenca alta del río Chama, estado Mérida-Venezuela. Revista Geográfica Venezolana 49(2):247–265

Ministerio de Agricultura y Tierras (MAT) (2007) Mérida. Algunos aspectos agrícolas del municipio Antonio Pinto Salinas. Material informativo. Ministerio de Agricultura y Tierras, Caracas

Moguel P, Toledo V (1999) Review: biodiversity conservation in traditional coffee systems in Mexico. Conserv Biol 13:11–21

Montagnini F, Suárez-Islas A, Araújo Santana M (2008) Participatory approaches to ecological restoration in Hidalgo, Mexico. Bois et Forêt des tropiques 295(1):5–20

Nawir AA, Kassa H, Sandewall M, Dore D, Campbell B, Ohlsson B, Bekele M (2007) Stimulating smallholder tree planting—lessons from Africa and Asia. Unasylva 228(58):53–58

Organización Internacional de Maderas Tropicales (OIMT) (2002) Directrices de la OIMT para la restauración, ordenación y rehabilitación de bosques tropicales secundarios y degradados. OIMT—Serie de políticas forestales N° 13, Yokohama

Pozzobon E, Hernández E, Dugarte I (2004) Evaluación del proceso de deforestación en tres cuencas del piedemonte lacustrino de la Cordillera de los Andes. Revista Forestal Venezolana 48(2):14–22

Ricketts T, Daily G, Ehrlich P, Michener C (2004) Economic value of tropical forest to coffee production. Proc Natl Acad Sci 101(34):12579–12582

Rojas-López J (2007) Venezuela: Cambios productivos y desafíos territoriales desde la geodiversidad de la agricultura. In: GEO-Venezuela: Geografía de la División Político-Territorial del País Número 2 Capítulo 25. Fundación Empresas Polar, Caracas

Rondón J (1991) Evaluación del impacto ambiental sobre la cuenca de la quebrada "San Isidro". Caso: construcción y funcionamiento de un dique toma. Municipio Autónomo Tovar, Edo. Mérida. Trabajo especial de grado, ULA, Mérida

Schirmer J (2007) Plantations and social conflict: exploring the differences between small-scale and large-scale plantation forestry. Small Scale For 6:19–33

Shono K, Cadaweng E, Durst P (2007) Application of assisted natural regeneration to restore degraded tropical forestlands. Rest Ecol 15(4):620–626

Torres-Lezama A, Ramírez-Angulo H, Vilanova E, Barros R (2008) Forest resources in Venezuela: current status and prospects for sustainable management. Bois et Forêt des Tropiques 295(1):21–33

Torres-Lezama A, Vilanova E, Ramírez-Angulo H (2009) Guiding principles for small-scale forestry in a watershed of the Venezuelan Andes: constraints and opportunities. Small Scale For 8(1):77–93

Wilken GC (1976) Integrating forest and small-scale farm systems in Middle America. For Ecol Manag 1:223–234. doi:10.1016/0378-1127(76)90027-X

Yuliani E, Tadjudin D, Indriatmoko Y, Munggoro D, Gaban F, Maulana F, Adnan H (eds) (2006) Multistakeholder forestry: steps for change. Center for International Forestry Research (CIFOR), Bogor